Three-Spacecraft Simulation for Viking 1975

M. M. Whang
DSN Data Systems Development Section

A telemetry simulation capability is provided at each Deep Space Station, by way of the Simulation Conversion Assembly (SCA), for testing station equipment and training of operations personnel prior to each mission. The simulation equipment provided to the DSN for support of the Viking 1975 mission has been substantially more complex than that provided for previous missions. No single station in the DSN has had the requirement to track three spacecraft simultaneously for any past flight project. Deep Space Stations will be required to support the equivalent of four spacecraft (two orbiters and two landers) for the Viking 1975 mission.

However, any single station will have a view angle of the equivalent of only three spacecraft maximum at any given time (two orbiters and one lander). Since each spacecraft has two telemetry channels (one science and one engineering channel), the Deep Space Stations must be prepared to process six channels of telemetry data and hence a six-channel simulation capability must be provided. This entails the generation of an additional two channels of simulated telemetry data over the present four-channel capability of the Simulation Conversion Assembly. This article describes the SCA modification necessary to prepare for the Viking 1975 mission.

I. Introduction

The Simulation Conversion Assembly (SCA) provides a mission-independent source of simulated data for use in the checkout and test of telemetry data handling equipment at a Deep Space Station (DSS). The SCA is also a serial element of the DSN Simulation System with the DSS Telemetry and Command Data Handling Subsystem to process data generated at the Mission Control and Computing Center (MCCC) and distribute the data to the various equipment throughout the DSS, including the Subcarrier Demodulator Assembly (SDA), Symbol Synchronizer Assembly (SSA), Telemetry and Command Processor (TCP), Block Decoder Assembly (BDA), Digital Decoder Assembly (DDA), and the test transmitter assemblies. At present, all of the SCAs have been updated to support MVM'73. For the Viking 1975 mission, the SCAs at the 64-m stations (DSS 14, 43, and 63), and temporarily at CTA 21, will be updated to support mission requirements. At the 26-m stations, the SCA hardware will remain unchanged; however, new software capabilities are provided to support the project.

II. Viking 1975 Simulation Requirements

The simulation requirements imposed on the SCA by Viking 1975 are defined in detail in Ref. 1. The following paragraphs briefly describe these requirements as they specifically pertain to the SCA; for further information refer to Ref. 1.

The SCAs at the 64-m DSSs will be required to simulate high-rate (science) and low-rate (engineering) data for each of two orbiters and one lander spacecraft. The two orbiter high-rate channels will be required to provide block coded data at a maximum rate of 16.0 kbps and uncoded data up to 4 kbps. The orbiter low-rate channels will provide uncoded data at a maximum rate of 33-⅓ bps. The lander high-rate channel will be required to provide block coded data at a maximum rate of 1 kbps; the low-rate channel will provide uncoded data up to 8-⅓ bps.

Each of the six telemetry channels (channels 1 through 6–5 and 6 are new) will require biphase modulation. The orbiter high-rate channels will be modulated by a subcarrier frequency of 240 kHz, the low rate at 24 kHz. The lander high-rate channel will be modulated by a subcarrier frequency of 72 kHz, the low rate at 12.0 kHz.

The 64-m DSSs will also require a third test translator with associated modulator, mixer, and modulation index control to provide for new channels. The test translator RF carrier will be 2.11 GHz.

The SCAs at the 26-m DSSs will require a four-channel (existing channels 1 through 4) simulation only. The data rates, formats (uncoded or block coded), and subcarrier frequencies are the same as for the 64-m DSSs. These stations will be required to simulate high- and low-rate data for each of two orbiters (four channels) or high and low rate for one orbiter and one lander.

The existing SCA software, DOI-5089-TP-C (DROP C), will require updating to become DOI-5089-TP-F (DROP F). The new software will provide for maximum control of the hardware at the 64-m DSSs. The same software will also provide for control at the 26-m DSSs. In addition to hardware control and high-speed data line (HSDL) (bit stream) data routing, the software will be required to simulate the following fixed data outputs (maximum capabilities):

(1) Two orbiters:

   (a) Visual Imaging Science (VIS) data (high-rate data with incrementing line and picture counts); capabilities provided on telemetry channels 1, 2, 5, and 6; capabilities exist at 26-m (channels 1 and 2 only) and 64-m DSSs.

   (b) Viking Orbiter Science (VOS) data (high-rate, fixed data); channels 5 and 6 only; capabilities exist at 64-m DSSs only.

   (c) Viking Orbiter Engineering Launch (VOEL) data (low-rate, fixed data); channel 4 only; capabilities exist at 26- and 64-m DSSs.

   (d) Viking Orbiter Engineering Cruise (VOEC) data (low-rate, fixed data); channel 3 only; capabilities exist at 26- and 64-m DSSs.

(2) One lander:

   (a) Visual Imaging Lander (VIL) data (with incrementing line and picture counts); capabilities provided on telemetry channels 1 and 2 only (26- and 64-m DSSs).

   (b) Viking Lander Engineering Format 4 (VLE4) and SSCA (surface sampler) low-rate, fixed data; channel 1 only (26- and 64-m DSSs).

   (c) Viking Lander Engineering Format 5 (VLE5) (low-rate, fixed data); channel 2 only (26- and 64-m DSSs).

III. Existing SCA Capabilities

At present, the SCA is capable of simulating four channels (channels 1 through 4) of telemetry data. Two of the channels (channels 1 and 2) have block coding, high- and low-rate capabilities. The other two channels provide uncoded low-rate data only. Each of the four channels can be biphase (BI-ϕ) or interplex-modulated.

The SCA also provides a computer-controlled data selection matrix which provides for modulation control, modulation index setting, and test signal routing to various DSS equipment.

The existing software provides for control of the SCA hardware, input and processing of HSDL inputs from MCCC, and MVM'73 fixed data simulation of Imaging 1 (IM-1) at 117.6 kbps. The IM-1 data were embedded in the MVM'73 SCA software.

For purposes of Viking 1975, the 26-m stations will retain the existing hardware capabilities; however, new software will provide for the required fixed data simulations described in Section II.

IV. New SCA Capabilities Required

In addition to the existing capabilities described in Section III, the 64-m DSSs will be required to provide two new telemetry channels (for a total of six), with associated block coders and variable data-rate capabilities.

Two new modulators are required to provide two additional biphase outputs. These modulators will be identical to the four existing modulators and will also be capable of providing interplex modulation. A new mixer, with associated modulation index setting capabilities, and a power amplifier will be required to provide for a third transmitter test signal. The SCA data selection capabilities will be expanded to provide for routing of the two new channels, and for increased test signal outputs to an increased number of DSS equipments.

In addition to the new hardware required, a new software SCA Data Routing Operational Program (DROP) is required to provide for control of the new hardware and also to provide two additional telemetry channel outputs and simulation of the fixed data described in Section II. This program must be compatible for use at both the 26- and the 64-m DSSs.

V. Implementation of New Capabilities

The SCAs at the 64-m DSSs will be updated to meet the requirements of Viking 1975. These modified SCAs will be redesignated to become the SCA II. At present, the SCAs at CTA 21 and DSS 14 have been updated and are in use. The SCAs at DSSs 43 and 63 will be updated in the near future.

The SCA II is basically an add-on and expansion of the existing SCA configuration. The requirement for a six-channel simulation is satisfied by adding two new telemetry channels (5 and 6) to the existing four-channel configuration. The two new channels are capable of providing high or low rate, block coded or uncoded data outputs.

Since three channels of high-rate data and three channels of low-rate data must be simulated, the SCA II will provide expanded bit rate capabilities. This was accomplished by adding one new bit sync generator and a frequency divider network. The bit sync generator provides the basic timing clock for the new telemetry channel 5. The frequency divider provides for selection of either low rates, or bit sync generator rates, for existing telemetry channels 1 and 2. Channel 3 and 4 bit rates are also selectable and are obtained from an existing fixed-rate generator (low rates) or from a bit sync generator. Telemetry channel 6 receives a bit rate input from existing bit sync generator 2 (BSG 2).

Four new video conditioner modulators, with biphase and interplex modulation features, will be added to provide a total of eight video conditioner outputs. New video conditioners 5 and 6 will provide for modulated or unmodulated outputs of the two additional telemetry channels. Video conditioners 5 and 6 are also interconnected to provide for interplexed data outputs. These two video conditioners provide outputs and modulation index setting for a third test transmitter signal.

Video conditioners 5 and 6 receive subcarrier frequency inputs from the new frequency divider network. A new, fourth, subcarrier frequency generator (SFG) is provided for a basic frequency input to the frequency divider, and for subcarrier input to video conditioner 7. The three SFGs contained in the existing SCA configuration provide for SFG inputs to video conditioners 1, 2, 3, 4, and 8.

New video conditioners 7 and 8 will be installed at DSSs 43 and 63 only, and will provide test signal inputs to eight SDAs.

The SCA II contains expanded data selection capabilities to provide for six-channel routing, modulation control, and modulation index control. The new capabilities also provide further test signal inputs to more DSS interfacing equipment. This is accomplished by expanding the basic design of the existing data select drawer to provide a new drawer. The new drawer will provide for routing any one or all or any combination of the six telemetry channels, data types nonreturn-to-zero level (NRZL) or nonreturn-to-zero mark (NRZM), to the following units, as the test data described:

(1) Bit error rate (BER) outputs to a maximum of five SSAs (NRZL only) and three TCPs.

(2) Word error rate (WER) (channels 1, 2, 5, and 6 only, with block coding capabilities) outputs to a maximum of five Data Decoder Assemblies (DDAs) and three Block Decoder Assemblies (BDAs).

(3) Convolutional error rate (CER) (channel 1 only) outputs to a maximum of five DDAs.

(4) Bit sync (BS) outputs to three TCPs.

The data select drawer also provides for modulation control of the video conditioners and for control of the modulation index attenuators contained within the video conditioners. These capabilities will provide for biphase or interplex modulation of test signal outputs to a maximum of eight SDAs (four new), nonmodulated data outputs to a maximum of five SSAs, and nonmodulated outputs to provide for integrated, low-rate inputs to eight TCPs. Eight modulation index attenuators can be controlled to provide settings for paired inputs (1 and 3, 2 and 4, 5 and 6; 7 and 8 are not used) to associated mixers for test signals to three transmitters.

The existing SCA hardware configuration consists of two standard buffer assemblies and a two-cabinet XDS 910 computer. This configuration will remain unchanged at the 26-m DSSs. At the 64-m DSSs a third buffer assembly with associated interfacing cables will be added to provide the hardware for the new capabilities required. The third cabinet will receive EOM/POT inputs directly from the computer via a PIN/POT expansion chassis added to the computer memory cabinet. A photograph of the new cabinet, buffer cabinet 3, is shown in Fig. 1, and the front and rear physical layouts are shown in Fig. 2. The SCA II installation at CTA 21 is shown in Fig. 3. Note that the SCA II consists of, from left to right, the new buffer cabinet 3, existing buffer cabinets 1 and 2, and two XDS 910 computer buffer cabinets.

The new DROP program is compatible for operation at both the 26- and 64-m DSSs. At the 64-m DSSs the program provides for control of the maximum hardware control capabilities and the fixed data outputs described in Section II. Throughout the design and development of the SCA II, the software development presented the most problems. In order to accomplish all of the software requirements, some of the software functions were incorporated into the SCA II hardware.

Reference

1. Davis, E. K., and Mudgway, D. J., *Deep Space Network Support Plan for the Viking '75 Project*, Project Document 614-19 (Change 2), Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1973 (an internal document).

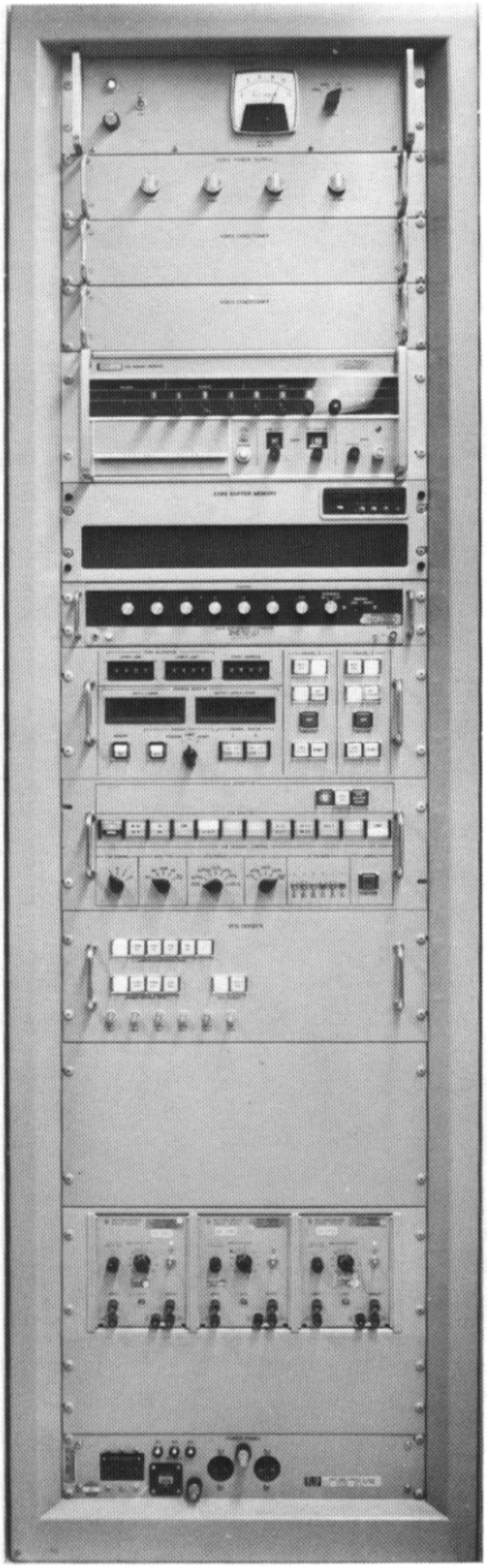

Fig. 1. SCA II buffer cabinet 3, front view

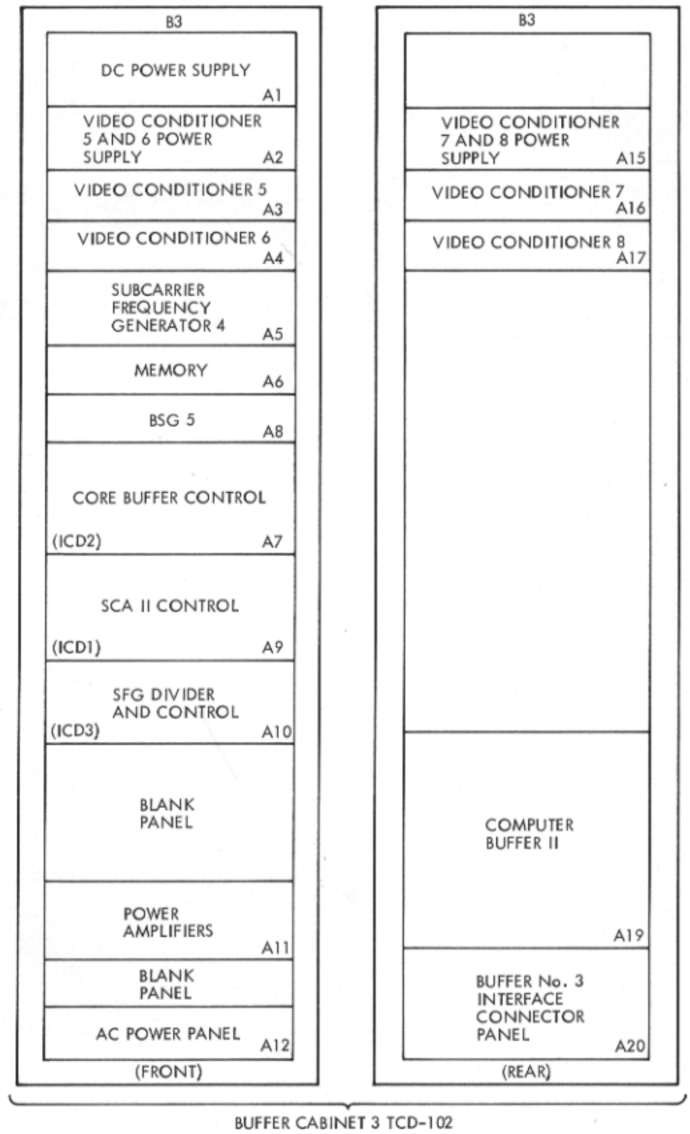

Fig. 2. SCA II buffer cabinet 3, physical layout

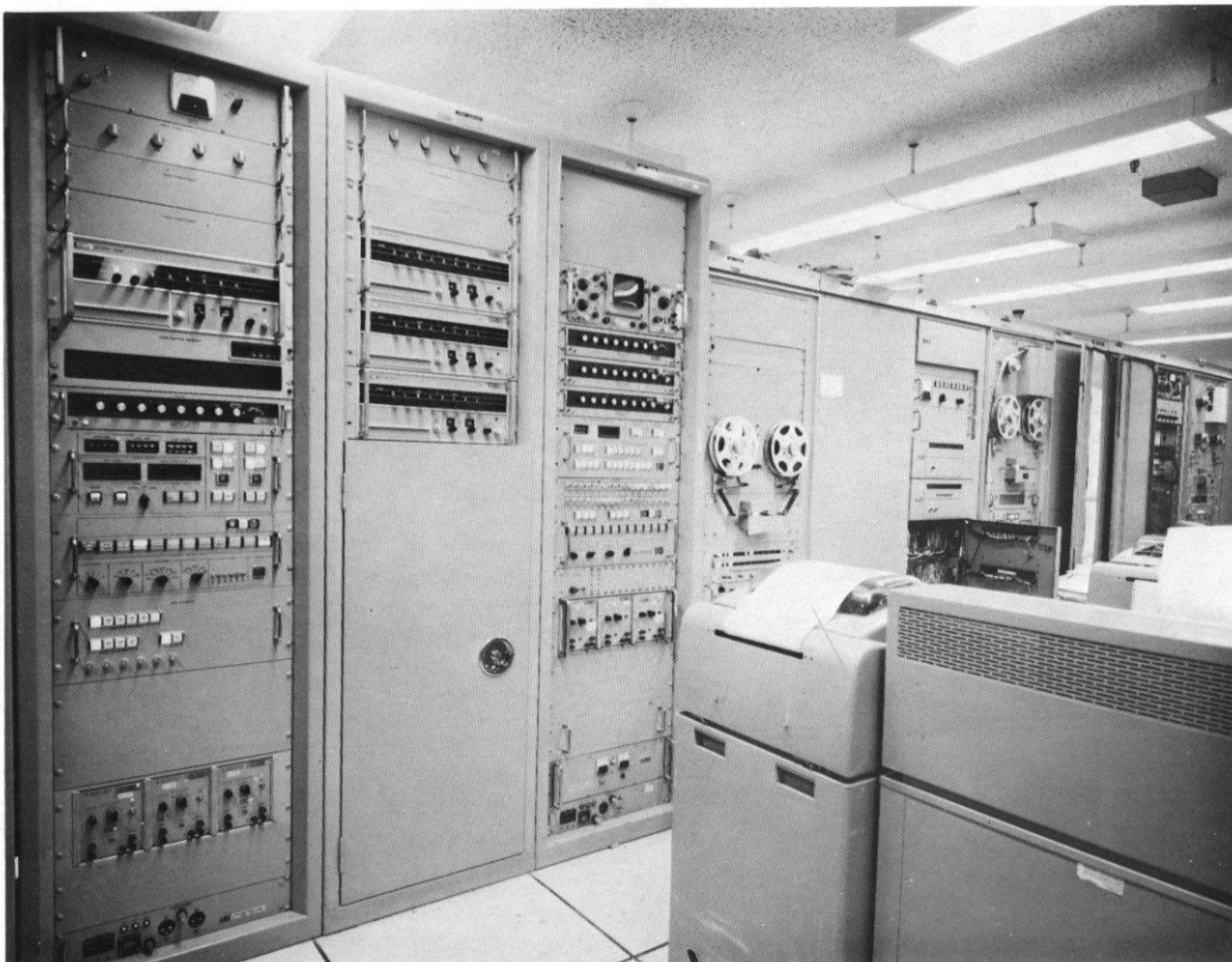

Fig. 3. SCA II installation at CTA 21